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Combined Effect of 1-MCP with Honeybee Wax on Plum Quality during Cold Storage

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ABSTRACT

Post-harvest treatment plays a significant role in extending the shelf life of fresh produce. This study was conducted with the aim to evaluate the efficacy of post-harvest 1-MCP and bee wax treatment on plum quality under cold storage condition (3±1°C, RH; 80-85%). Fruit were divided into 9 groups and subjected to different treatments i-e T_0 (untreated) T_1 (1-MCP 0.5µl/L), T_2 (1-MCP 1µl/L), T_3 (5% bee wax), T_4 (10% bee wax), T_5 (1-MCP 0.5µl/L+5% bee wax), T_6 (1-MCP 0.5µl/L+10% bee wax), T_7 (1-MCP 1µl/L+5% bee wax), and T_8 (1-MCP 1µl/L+10% bee wax). Various physicochemical and sensory quality attributes were evaluated at 12 days intervals for 60 days. The results for the sample T_8 revealed lowest decrease in ascorbic acid (10.15%), titratable acidity (15.05%), overall acceptability (34.52%) and lowest percent increase weight loss (2.71%), total soluble solid (18.40%), total sugar (19.49%), pH (11.63%).While T_0 showed highest percent decrease in ascorbic acid (41.67%), titratable acidity (55.91%), overall acceptability (74.80%) and highest increase in percent weight loss (14.34%), total soluble solid (30.82%), total sugar (30.50%), pH (22.45%). Therefore, it could be concluded that T_8 demonstrated good results for physicochemical and sensory characteristics during cold storage treatment. Furthermore, combination of 1-MCP and bee wax could be used to preserve the internal and external quality.

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INTRODUCTION

Plums (*Prunus domestica* L.) belongs to family Rosacea of genus Prunus and deciduous in nature, generally kept under the stone fruits. It is a major fruit of Pakistan and grown in temperate regions and milder sub-tropical regions of Khyber Pakhtunkhwa (Sohail *et al.,* 2014). Plum fruit is of great importance stone fruits after peach regarding area and production. In Pakistan, it is generally grown in KPK and Balochistan provinces. The major varieties of plum in swat are Fazlemanani, Faramusa, Red beauty and late manani (Shahzad *et al.,* 2013). Pakistan total part under plum is about 7 thousand hectares and total production is 54.5 thousand tones. Where in KPK, total area is about 3 thousand hectares and production are 25.5 thousand tones. (Fruit, Vegetable and Condiments Stat of Pak. 2015-16). Plum is a fleshy fruit having composition, moisture content (87.23%), energy (46 kcal), protein content (0.70g), carbohydrate (11.42%), calcium (6mg), riboflavin (0.026 mg), niacin (0.417mg), vitamin c or ascorbic acid (9.5mg), phosphorous (16mg), potassium (1.7mg) iron (0.17mg) per 100 grams of edible portion (USDA, 2016).

Quality deterioration take place just after the harvest of fresh fruits due to its living tissues and ultimately biochemically and physiologically changes occurs resulting in detrimental changes in shelf life and quality of produce. The factors responsible for the deterioration of fruits and vegetables are respiration, transpiration ethylene production (Deell *et al.,* 2003). As plum is a perishable in nature, such soft nature is vulnerable to post harvest losses at various conditions and levels of storage and marketing. Post-harvest losses technically refer to the quantitatively and qualitatively damages such as change in availability, edibility and quality of production at various levels of transportation from picking to consumption (Troger *et al.,* 2007).

Ethylene, the plant growth regulator effects the growth and development processes and also causes the ripening and senescence of fruits (Abeles *et al.,* 1992). 1-methylchlopropene (1-MCP) is constructed to be responsible to inhibit ethylene production and also reduce the senescence and ripening of both climacteric and non-climacteric vegetables and fruits. 1-MCP cooperate and lock the ethylene receptor and ethylene dependent reaction (Silser and Serek, 2003). The delay in physiochemical changes, ripening process, as well as reducing the denaturing process, weight loss and chilling injury are beneficial aspects of 1-MCP treatments. For maintaining the quality and extend shelf-life of fruit and vegetables, 1-MCP is an efficient and commercial tool for species of genus prunus (plum, peach, and apricot) has been treated with concentrations of different ranges and various temperature regimes. The limits of temperature during application are (between 1 to 20^{o}C), there is no clear evidence of effectiveness between temperature and 1-MCP (Blankenship and Dole, 2003).

The demand for hygienic food and nutrition along with environmental conditions coating and edible film is of great interest to consumers. The principal purpose of coating material and edible films is to protect food from external agencies and hence works as a barrier to moisture, oxygen and flavor. Generally coating materials and edible films are considered as safe for human consumption. Such treatment with fruits may allow reduction in moisture loss in fruits and allow respiration as modified atmospheric packaging (Banks *et al.,* 1993; Zevallos and Krochta, 2002).

As the summer temperature rises the ripening occurs with peak production season of this variety Fazlemanani (Sohail *et al.,* 2014). Due to high perishable and soft nature fruit its shelf life varies from 3-6 days. Cold storage at 0^{o}C is recommended for quality and shelf life improvement (Velardo *et al.,* 2010). The shelf life of plum after harvesting is short therefore it marketing is difficult both international and national levels for extending plum shelf life, unfortunately limited work has been done is in Pakistan. This research was conducted for developing technology to extend the plum shelf life and to find an effective and economical control for minimizing the losses during storage and to generate larger revenues for all stake holders. Therefore, this research focuses on the possibility of combining of 1-MCP and beeswax to determine it useful effect. The main objectives of the study were to study the effect of 1-MCP in combination with beeswax on the physiochemical parameters of plum fruit during cold storage and determine the effectiveness of 1-MCP and beeswax treatment in improving the storage life of plum fruit.

MATERIALS AND METHODS

Plum fruit (*Prunus domestica*) variety, of same size, free from injuries and infections at their proper physiological maturity and firm texture were hand-picked from the local orchard and packed in paper boxes and were transported to Food Technology Section, Agriculture Research Institute (North) Mingora Swat.

Preparation of Coating Materials

Beeswax in Paraffin Oil

Solid beeswax at the rate of 5g and 10g was completely dissolved through heating in 95ml and 90ml of paraffin oil respectively. After dissolving, it was allowed to cool down and a jelly like structure was obtained (Mladenoska, 2012).

1-MCP Application

The gaseous 1-MCP was generated by adding smart fresh powder (0.14% active ingredient Agro Fresh-Hohm and Haas Company) with distilled water in portable chamber. Plum fruits treated with gaseous 1-MCP at 20℃and placed for 24 hours in a closed chamber having small fans to ensure that 1-MCP gas was evenly diffused around the fruits.

Table 1. Plan of study.

Treatments	1-MCP	Beeswax	1-MCP+beeswax
T0	Control (untreated)	Control (untreated)	Control (untreated)
T1	1-MCP (0.5 µl/L)		
T2	1-MCP (1 µl/L)		
T3		Bee wax (5%)	
T4		Bee wax (10%)	
T5			1-MCP (0.5 µl/L) + beeswax (5%)
T6			1-MCP (0.5 µl/L) + beeswax (10%)
T7			1-MCP (1 µl/L) + beeswax (5%)
T8			1-MCP (1 µl/L) + beeswax (10%)

Storage

All treated and untreated (control) fruit were stored in commercial cold store (operating at 3±1°C and relative humidity of 80-85%) and the measurement was recorded on the day of harvest, 12 days interval during cold storage on the following quality parameters until 50% spoilage of fruit samples.

Data collection

For data analysis equal fruits from each treatment were taken for quality parameters and overall acceptability. The treatments were analyzed at 12 days interval for total period of 60 days. With the help of digital electronic balance, the fresh weight in grams of each sample was recorded after 12 days of interval (AOAC, 2012). Using digital refractometer at room temperature the total soluble solid (TSS) was recorded by prescribed procedure of AOAC (2012). Titratable acidity was determined through standard alkali solution by the standard prescribed procedure as recommended in (AOAC, 2012). The ascorbic acid concentration in a solution was determine by redox titration by mean of iodine Seamus (2005). Total sugar was obtained by the process describe by devi (2005). With the help of digital meter, the pH of the sample can be recorded as shown standard method as reported by (AOAC, 2012). The total treatments of plum fruits were analyzed by means of overall acceptability by trained panel of judges according to (Larmond, 1977). The data evaluation by assigning score value ranges from 1-9, where 1 and 9 is stands for extremely like, and extremely dislike respectively.

Statistical Analysis

All the data concerning different parameters as mean of triplicate was analyzed statistically using completely randomize design (CRD) through Statistix 8.1 software. LSD test was used to separate means as stated by (Steel and Torrie, 1997).

RESULT AND DISCUSSION

Plum fruits were treated with1-MCP (0.5 µl/L)**,** 1-MCP (1 µl/L), beeswax (5%),beeswax (10%),1-MCP (0.5 µl/L) + beeswax (5%),1-MCP (0.5 µl/L) + beeswax (10%),1-MCP (1 µl/L) + beeswax (5%),1-MCP (1 µl/L) + beeswax (10%) which were name as T_1, T_2, T_3,T_4, T_5, T_6,T_7,T_8,respectively.T_0 were kept as control with no treatment applied. The samples were analyzed for physiochemical and sensory evaluation. (Percent weight loss, TSS, titratable acidity, ascorbic acid, total sugar, pH and overall acceptability).

Percent Weight Loss (%)

According to these results minimum percent weight loss (69.73%) was observed in T_8 while the maximum weight loss (75.48%) was observed in control. In response to storage intervals higher mean value for weight loss (6.29%) was recorded after 60 days while lower mean value (1.62%) was recorded after 12 days interval. Percent weight loss was significantly ($P \leq 0.05$) affected by treatments and storage intervals of plum fruit. Percent weight loss may be due to respiration, transpiration and metabolic activity (Yaman and Bayoindril, 2002). Edible coating has inhibited barrier properties to CO_2, O_2, water vapor and moisture (Raghav *et al.,* 2016; Znidarcic *et al.,* 2010;Rozo-Romero *et al.,* 2015). 1-MCP has the ability to inhibit the plant tissues to give response to ethylene (Sisler and Serek, 2003) and therefor it delays the ripening of fruit and control loss of fruit mass in many climacteric fruits (Blankenship *et al.,* 2003; Watkins, 2006). Our result is in line with that of

(khan and singh, 2008; Barbosa *et al.,* 2005; Parra-Coronado *et al.,* 2008) they proposed that use of 1-MCP can reduce weight loss of plum fruits during storage. The combination of 1-MCP and beeswax give a synergistic effect to preserve internal and external qualities of fruits (Machado *et al.,* 2009).

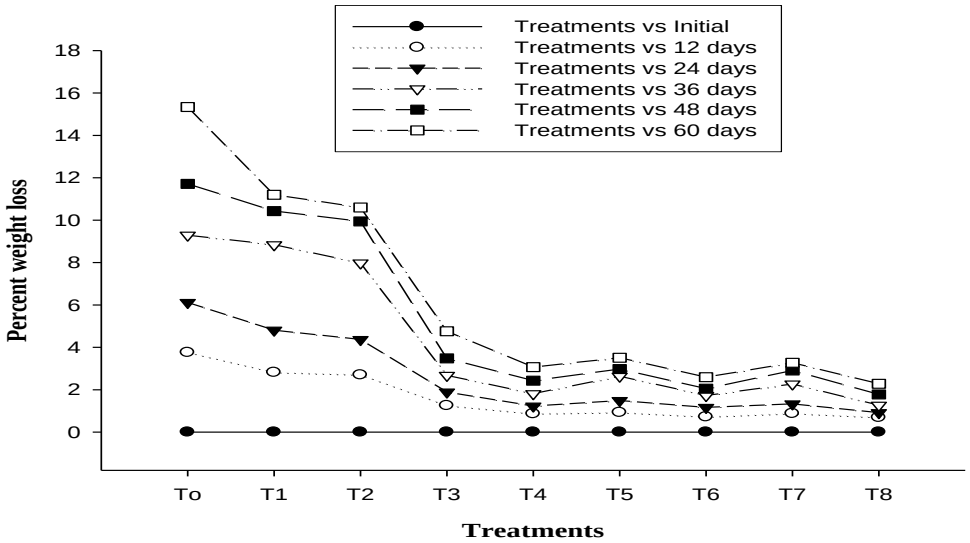

Figure 1. Effect of 1-MCP with beeswax and Storage intervals on % weight loss of Plum fruit.

Total Soluble Solids TSS (^{0}brix)

The effect of treatments and storage intervals on total soluble solids in plum fruit. Analysis of the data indicated that total soluble solids was significantly affected by treatments and storage interval. In response to treatments higher mean (12.27%) was observed at T_0 (control) followed by T_1 (12.05%) while the lower mean (11.23%) was observed in T_8 trailed by T_6 (11.32%). In response to storage intervals higher mean for total soluble solids (13.62%) was recorded after 60 days while lower mean (10.61%) was recorded at 12 days interval. Gradual increase in TSS were observed with increasing storage time. This rise in total soluble solids might be due to enzymatic conversion of higher polysaccharide such as pectins and starches into simple sugars and loss of water during ripening stage of plum fruit (Goni *et al.,* 1997; Hussain *et al.,* 2008; Majeed and Jawandha, 2016). Menniti *et al.* (2004) and Dong et al. (2002) Observed slightly effect of 1-MCP on TSS content of plum fruit. It is observed that coating of fruit with beeswax reduced the increase in total soluble solids as compared to fruits that are uncoated under storage condition (Shahid and Abbasi, 2011). The combination of 1-MCP and beeswax give a synergistic effect to maintain the total soluble solid of fruit. (Machado *et al.,* 2009).

Acidity (%)

Analysis of the data indicated that acidity was significantly affected by treatments and storage interval. In response to treatments higher acidity mean was observed at T_8 (0.87%) followed by T_7. The lower acidity mean was observed in T_0 (0.69%). In response to storage intervals higher mean value for acidity was recorded after 12 days (0.90%) while lower mean value (0.65%) was recorded after 60 days of storage. The changes in total titratable acids throughout storage was mostly due to the metabolic activities of living tissues during which reduction of organic acids takes place (Bhattarai and Gautam, 2006). Fruit treated with 1-MCP maintained higher acidity, which could be due to a decrease in respiration rates as observed in different plum cultivars (Dong *et al.,* 2002; Argenta *et al.,* 2003; Salvador *et al.,* 2003. Similar phenomenon is also observed by (Jan *et al.,* 2012) and discussed that TA of the apple fruit is affected by rate of respiration which consume organic acid, and thus the acidity reduces with increase in respiration rate. The combination of 1-MCP and beeswax give a synergistic effect to preserve titratable acidity of fruit. (Machado *et al.,* 2009).

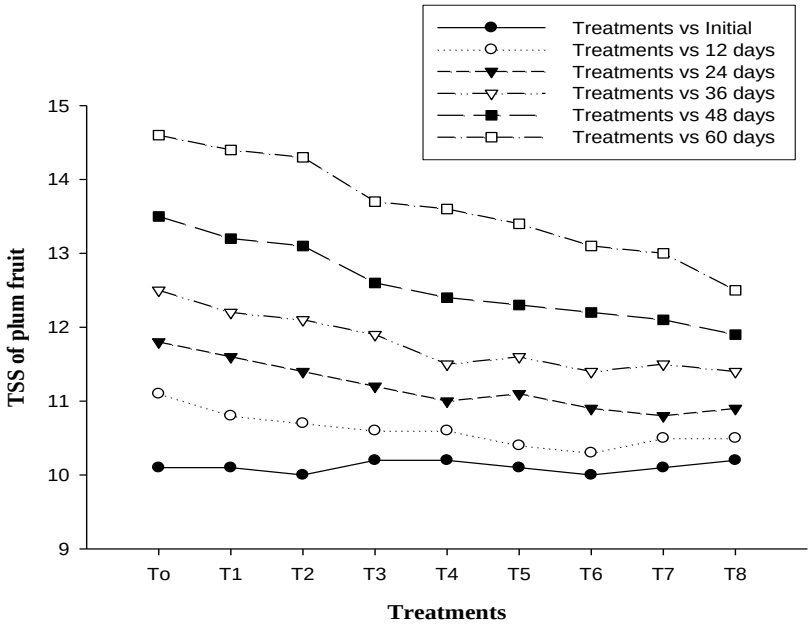

Figure 2. Effect of 1-MCP with beeswax and Storage intervals on total soluble solids TSS (^{0}brix) of Plum fruit.

Acidity (%)

Analysis of the data indicated that acidity was significantly affected by treatments and storage interval. In response to treatments higher acidity mean was observed at T_8 (0.87%) followed by T_7. The lower acidity mean was observed in T_0 (0.69%). In response to storage intervals higher mean value for acidity was recorded after 12 days (0.90%) while lower mean value (0.65%) was recorded after 60 days of storage. The changes in total titratable acids throughout storage was mostly due to the metabolic activities of living tissues during which reduction of organic acids takes place (Bhattarai and Gautam, 2006). Fruit treated with 1-MCP maintained higher acidity, which could be due to a decrease in respiration rates as observed in different plum cultivars (Dong *et al.,* 2002; Argenta *et al.,* 2003; Salvador *et al.,* 2003. Similar phenomenon is also observed by (Jan *et al.,* 2012) and discussed that TA of the apple fruit is affected by rate of respiration which consume organic acid, and thus the acidity reduces with increase in respiration rate. The combination of 1-MCP and beeswax give a synergistic effect to preserve titratable acidity of fruit. (Machado *et al.,* 2009).

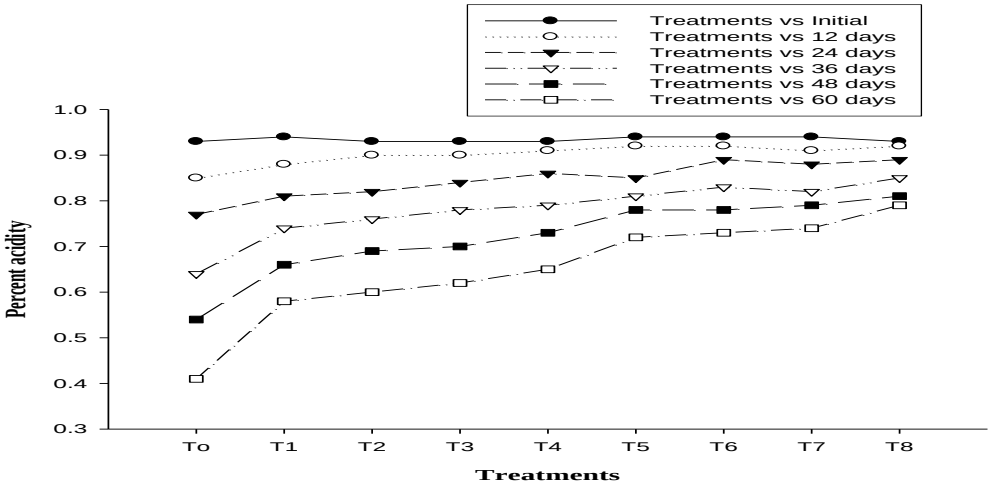

Figure 3. Effect of 1-MCP with beeswax and Storage intervals on acidity (%) of Plum fruits.

Ascorbic Acid (mg/100g)

Analysis of data Showed that treatments and storage interval had significant effect on vitamin C in plum fruit. In response to treatments lower ascorbic acid mean was observed at T_0 (6.41%) while the higher ascorbic acid mean was observed in T_8 (7.70%) trailed by T_7 (7.57%). In response to storage intervals higher mean value for ascorbic acid was recorded after 12 days (7.73%) while lower mean value was recorded after 60 days (6.21%). Ascorbic acid decreases due to the action of enzyme called ascorbic oxidase (Bhattacharya, 2004). Same result was obtained by Sivakumar et al. (2012) reported that highest vitamin C content in mango fruit treated with 1-MCP as compared to control treatment. These results are in line with (Kumar *et al.,* 2000). In storage condition if temperature is low and storage interval is high, so a decrease occur in the ascorbic acid level of the fruit. Low oxygen penetration with coated plum fruit retard the oxidation of ascorbic acid and results in maintained level of ascorbic acid. Combining 1-MCP with beeswax has synergistic outcomes on extending the shelf life of plum under cold storage condition. Same results are also observed by (Yaman and Bayoundurlc, 2002; Zhou *et al.,* 2008.

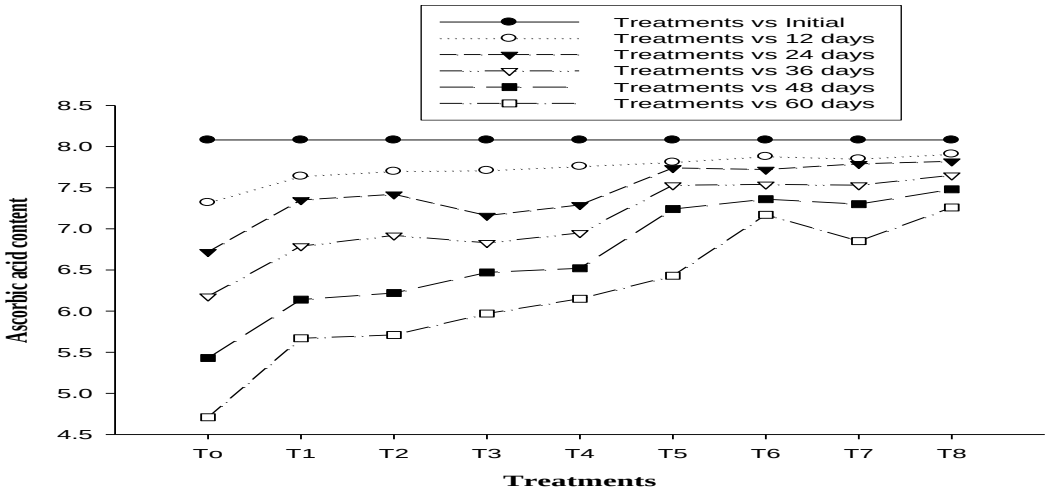

Figure 4. Effect of 1-MCP with beeswax and Storage intervals on ascorbic acid (mg/100 g) of Plum fruit.

Total Sugar (%)

Data regarding total sugar of plum fruit as affected by overall treatments and storage intervals. Minimum total sugar mean was observed in T_8 (10.92%) while maximum total sugar mean was observed (11.80%) in untreated or control. In response to storage intervals higher mean value for total sugar (13.21%) was recorded after 60 days while lower mean value (10.37%) was recorded after 12 days interval. Statistical analysis of the data showed that treatments and storage intervals had significant effect on total sugar of plum fruit. Prasanna et al. (2007) reported conversions of starch to sample sugar that results in the increasing total sugars. In our study not as much of rise in total sugar was recorded in coated plum fruit than control which might be due coating material that affected mitochondria and some enzymes activity and results in decreased rate of respiration. During storage condition, physically in fruit weight decrease leads to breaking downing cell wall of polysaccharides and consequences is higher fruit total sugar content (Hulme and Rhodes, 2001). The results are in line with (Mao *et al.,* 2007; Nascimento *et al.,* 2006; Li *et al.,* 2012) they stated that 1-MCP-treated banana, kiwi and mandarin resulted in slightly lowered total sugar as compared to control.

pH

Data regarding pH of plum fruit as affected by overall treatments and storage intervals. Minimum pH was observed in T_8 (4.08) while the maximum pH (4.37) was observed in untreated or control. In response to storage intervals higher mean value for pH (4.54) was recorded after 60 days while lower mean value (3.97) was recorded after 12 days interval. Statistical analysis of the data showed that treatments and storage intervals had significant effect on pH of plum fruit. Juice pH and titratable acidity showed an opposite relation with each other. pH value of the juice raised considerably regardless of treatments. Juice pH indicates composition

of acid. During respiration breakup of acids into sugar occur that result in decreased titratable acidity (Bhattatai and Gautam, 2006). It is the reason that the sour taste of plum fruit decreases as it goes towards maturation and ripening whereas value of the pH increases in storage condition. Emadpour *et al*. (2009) reported that 1-MCP treated fruits have lower pH value that of control fruits.

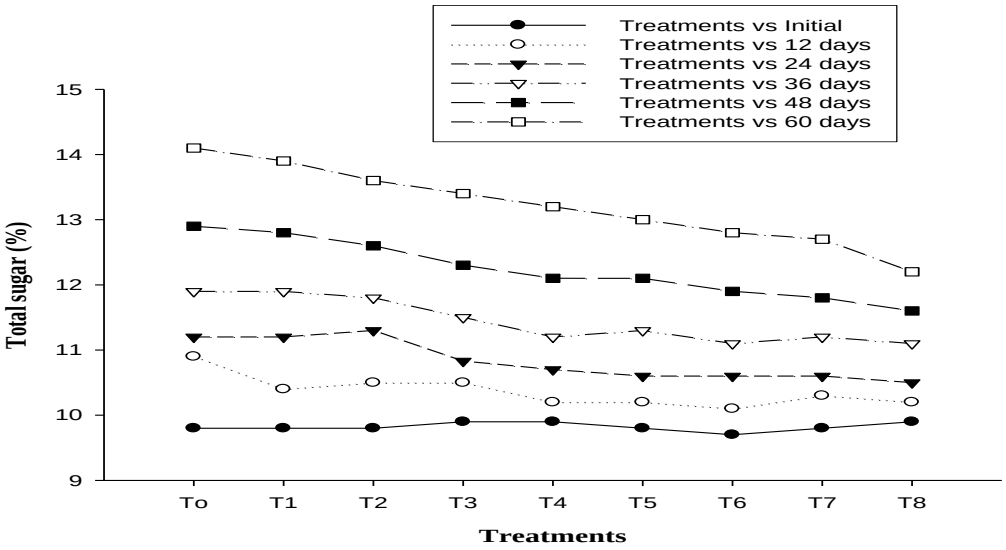

Figure 5. Effect of 1-MCP with beeswax and Storage intervals on total sugar (%) of Plum fruit.

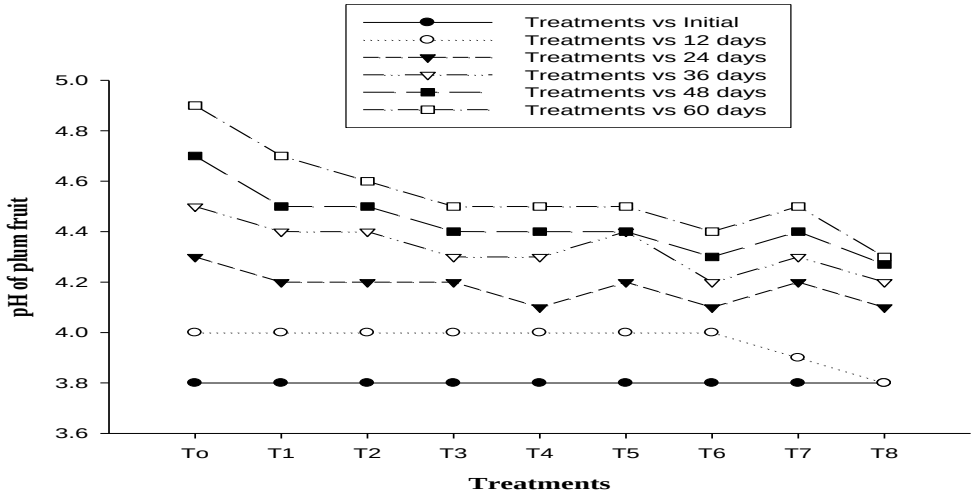

Figure 6. Effect of 1-MCP with beeswax and Storage intervals on pH of Plum fruit.

Overall Acceptability

Effect of different treatments and storage intervals on overall acceptability (mean score of judges) of plum fruit, maximum mean for fruit overall acceptability (7.01) was obtain from T_8 coated with beeswax and 1-MCP whereas minimum mean overall acceptability was observed in T_0 (5.37) control treatment. Maximum fruit overall acceptability was recorded (8.37) at initial day while the minimum fruits overall acceptability score (3.93) was observed at days 60. Statistical analysis of the data showed significant effect of treatments and storage interval on overall acceptability (mean score of judges) of plum fruit. In our study, less reduced mean score for judges of overall acceptability was recorded in coated plum fruit in comparison with control and this might be due barrier effect of coating material to losing volatile components as well water and also gaseous exchange. Hassan *et al*. (2014) observed a high mean score for

overall acceptability of judges in fruits coated with beeswax for flavor than other treatments and control. Sensory analysis showed much increase in storage condition at the end in coated fruit than uncoated which might be due to low production of ethylene and slow rate of respiration (Zapata *et al.,* 2008). These results are in line with (Reinoso *et al.,* 2008) who stated that coated plum was more satisfactory than the control.

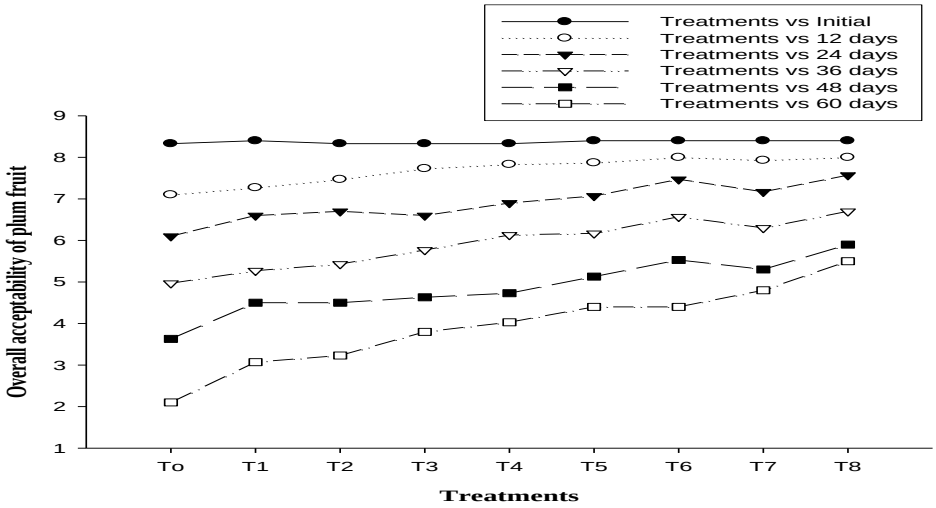

Figure 7. Effect of 1-MCP with beeswax and Storage intervals on overall acceptability of Plum fruit.

CONCULSIONS

It was concluded from the results that 1-MCP in combination with beeswax (1-MCP 1µl/L+10% beeswax) resulted best for all parameters to prolong the storage life of plum fruit during cold storage as compared with sole application of 1-MCP and beeswax in different concentrations whereas, control treatments were found least effective. 1-MCP and beeswax in combination delayed water loss, TSS, ascorbic acid, titratable acidity, total sugar, pH, and sensory quality of fruits in cold storage up to 60 days as compared to individually and control fruits. The same research should be repeated on other stone fruits as well. Different chemical like chitosan, Aloe vera gel and $CaCl_2$ should be used with 1-MCP treatment on other fruits. Microbiological research should need to carry out on other climacteric fruits along with 1-MCP treatments.

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